Preparing for Large Force Exercises with Distributed Simulation: A Panel Presentation

Peter Crane, Winston Bennett, Michael France
Air Force Research Laboratory (711 HPW/RHA)
6030 S. Kent St Mesa, AZ 85212, USA
1 480 988 6561
peter.crane@mesa.afmc.af.mil, winston.bennett@mesa.afmc.af.mil, michael.france@mesa.afmc.af.mil

Ebb Smith, Robert Anderson
Defence Science and Technology Laboratory
West Court, Level C Room C036
iSAT K, Desk 233
Portsdown West
Portsdown Hill Road
Fareham, PO17 6AD, UK
44 (0)2392 532929, 44 (0)2392 532922
mesmith@dstl.gov.uk, randerson@dstl.gov.uk

Jonathan Borgvall, Martin Castor, Niclas Lagerbäck, Patric Lavén
Swedish Defence Research Agency
Gullfossgatan 6, 164 90 Stockholm, Sweden
46 (0)8 5550 3000
jonathan.borgvall@foi.se, martin.castor@foi.se, niclas.lagerback@foi.se, patric.laven@foi,se

Andrew Robbie, Christopher Best
Defence Science and Technology Organization
Air Operations Division
506 Lorimer Street, Fishermans Bend, VIC 3207, Australia
61 3 9626 7252
andrew.robbie@dsto.defence.gov.au, christopher.best@dsto.defence.gov.au

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ABSTRACT: *Large Force Exercises such as Red Flag in the United States and Pitch Black in Australia require significant investments in resources and personnel. Participating units may spend months preparing for an LFE to ensure that warfighters receive the greatest training benefit from this investment. Local area training, however, cannot replicate the most demanding aspects of LFEs. Air Forces in the United Kingdom, Sweden, and Australia have used distributed simulation training to complement live-fly exercises to prepare for LFEs. In this panel presentation, the speakers will describe how training exercises using distributed simulation were structured and conducted to meet specific training goals. The panel will conclude with presentations on how detailed analysis of training needs is necessary to structure simulator scenarios and how future training exercises could be made more effective.*

1. Preparing for Large Force Exercises

Large Force Exercises (LFEs) are conducted by air forces to provide warfighters with opportunities to train for conducting composite force operations incorporating multiple aircraft types and missions. These missions include fighter interdiction, attack, air superiority, defense suppression, airlift, air refuelling, reconnaissance, close air support, and combat search and rescue. The goal is to provide realistic, combat training opposed by dissimilar adversary forces. Participating units may spend months preparing pilots, air battle managers, and other

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14. ABSTRACT
Large Force Exercises such as Red Flag in the United States and Pitch Black in Australia require significant investments in resources and personnel. Participating units may spend months preparing for an LFE to ensure that warfighters receive the greatest training benefit from this investment. Local area training, however, cannot replicate the most demanding aspects of LFEs. Air Forces in the United Kingdom, Sweden, and Australia have used distributed simulation training to complement live-fly exercises to prepare for LFEs. In this panel presentation, the speakers will describe how training exercises using distributed simulation were structured and conducted to meet specific training goals. The panel will conclude with presentations on how detailed analysis of training needs is necessary to structure simulator scenarios and how future training exercises could be made more effective.

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warfighters for an LFE to maximize training benefits. Many aspects of LFEs, however, cannot be practiced on local training ranges. These include ground and airspace procedures for large force packages, coordination with other elements of a strike package, coalition operations, and operations against dissimilar forces.

To mitigate the limitations on live-fly training, the United Kingdom's Royal Air Force (RAF), the Swedish Air Force (SwAF), and the Royal Australian Air Force (RAAF) used simulation-based training in preparation for upcoming LFEs. The RAF and SwAF used distributed simulation training to prepare fighter pilots for Red Flag exercises conducted in the southwest US while the RAAF prepared Air Battle Managers (ABMs) for a Pitch Black exercise in the Northern Territory of Australia. The US Air Force Research Laboratory (AFRL), Warfighter Readiness Research Division working in cooperation with the UK's Defence Science and Technology Laboratory (Dstl), the Swedish Defence Research Agency's Air Combat Simulation Centre (Flygvapnets Luftstridssimuleringscenter [FLSC]), and Australia's Defence Science and Technology Organisation (DSTO) helped to design and develop a program of simulator training for each nation's warfighters and to collect follow-on data at the exercise to evaluate the effectiveness of the training.

In this panel presentation, researchers from Dstl, FLSC, and DSTO will present summaries of their training needs, objectives, training programs, and data on the results of training. Because of the great differences in training needs, these training programs were markedly different from each other while using similar technologies. The last two presentations will describe how careful front-end analysis is required to design an effective training program and how future training programs can increase the effectiveness of simulator training for LFEs.

2. Red Skies to Red Flag

Ebb Smith and Robert Anderson (DSTL)

2.1 Red Skies

In 2005, Dstl and AFRL undertook a transfer of training study conducted as part of the UK's Mission Training through Distributed Simulation research programme. The study was implemented via a synthetic collective training exercise, Trial Red Skies, under the auspices of the Coalition Mission Training Research programme, a three-nation collaborative activity which has been influential in the development of both the Mission Training through Distributed Simulation and the US Distributed Mission Operations initiatives. The overall aim of the trial was to provide training transfer for RAF combat-ready front-line Tornado GR4 crews and USAF F-16 pilots about to deploy on Exercise Red Flag in March 2005.

Whilst UK crews carry out a pre-Red Flag work-up on the squadron before deploying to Nellis AFB, this training mainly concentrates on Operational Low Flying proficiency and currency and, constituted four-ship work-up training. The Red Skies trial was thus designed specifically to provide Red Flag familiarisation where crews could plan and execute a typical Red Flag sortie using all the published planning documents. The airspace around the range is particularly busy and restrictive. Within the range itself, there are two particularly sensitive ranges, violation of one results in the crew being sent home and violation of the other could result in the squadron being grounded for the following day's flying. It is imperative that crews, especially first timers, are fully conversant with these restrictions.

Trial Red Skies took place during the week 28th February to 4th March 2005 and utilised the Aircrew Training Research test-bed at QinetiQ, Bedford. The trial was designed to support training for aircrew prior to their participation in the March 05 Exercise Red Flag. The trial involved operational UK Tornado GR4 aircrew from 13 Squadron RAF Marham, E-3D aircrew from Air C2 Operational Evaluation Unit, RAF Waddington, and USAF F-16 aircrew from the 113th Fighter Squadron, Terra Haute, Indiana.

The synthetic environment for this exercise included virtual and computer generated Red and Blue forces within a networked, operationally realistic and highly dynamic scenario comprising Integrated Air Defence System, Electronic Warfare and a real-world terrain data base of the Nellis Air Force Base Range Complex, Nevada. A secure network link to the AFRL in Mesa, Arizona enabled the US aircrew to plan, brief, fly and debrief with the UK crews during a week-long simulated Red Flag exercise. Staff from the Air Warfare Centre Tactical Team provided White Force support to optimise the operational value and act as subject matter experts for the Dstl assessment team. The basic experimental design, including simulators, network infrastructure and Trans-Atlantic links to US, were similar to those used in previous Dstl - AFRL trials. A distributed synthetic environment was thus created in which operational aircrew, based in the UK and US could perform together a Composite Air Operations training exercise based on Red Flag scenarios. The trials were designed so that participating aircrew could plan, brief, fly and debrief missions, mirroring the Red Flag training experience. For all missions, the Red Flag procedures, training rules and Standard Operating Procedures were followed.

The intent was to undertake a transfer of training study to establish whether Red Skies had provided participating UK and US crews with experiences that would better prepare them for Red Flag and which supported development of skills that would transfer to the live event. In order to do this, crews were to fly the same constituted four-ships as they would in Red Flag to enable a direct comparison in performance to be made. Air Interdiction, Close Air Support, and Time Sensitive Targeting missions were flown each day and the White Force included two, front-line Forward Air Controllers (FAC) from Delhi Barracks, Tidworth. In real-world operations, they provide the FAC element of the Tactical Air Control-Party.

The trial was successfully accomplished with positive feedback from all UK participants.

2.2 Red Flag

Dstl and AFRL also attended the live Exercise Red Flag at Nellis AFB, Nevada, as part of the 13 Sqn detachment, to complete the data gathering needed to undertake a transfer of training study. As in Red Skies, the GR4 crews flew both Air Interdiction and Close Air Support / Time Sensitive Targeting missions. The major differences were the number of participants (over eighty aircraft) and both day and night missions were flown.

2.3 Results and Conclusions

Following Red Flag a comprehensive data processing and analysis activity was undertaken, including follow-up interviews with trial participants. Aircrew feedback was positive on the training value of the Red Skies spin-up week and results indicated that training transfer was achieved. The results also reinforced the findings of previous trials. This indicates that the Mission Training through Distributed Simulation concept of training is valid and could be considered under new initiatives to transform training for the UK RAF.

3. Red Flag Spin-Up Experiences

Jonathan Borgvall, Martin Castor, Niclas Lagerbäck, and Patric Lavén (FLSC)

In 2008 the Swedish Air Force (SwAF) participated in Red Flag Nellis for the first time (SwAF participated in Red Flag Alaska 2006). Seven JAS39 Gripen fourth-generation fighters and 14 pilots deployed to Nellis AFB, NV, for the two week exercise. This paper describes the preparatory simulator exercise Red Flag Spin Up (RF spin-up) that was conducted at the SwAF Combat Simulation Centre (FLSC) about one and a half months prior to the live exercise. The primary focus here is how RF Spin-up was balanced, structured, and conducted to meet specific objectives and training goals with the support of training needs analysis.

3.1 Background

The SwAF runs a program for simulator-based training, research, development and acquisition at FLSC. The main objective is training of fast-jet pilots and the facility is designed to provide experiences that develop the trainees' knowledge and skills in decision making, planning, communication, tactical execution, and situational awareness. Training audiences include fighter pilots, fighter controllers/allocators, and forward air controllers (FAC). The emphasis is on developing skills and knowledge on a team and inter-team level using eight fast-jet cockpits, four fighter controller stations, and one FAC station. The research activities are mainly focused on training effectiveness and human performance, while the development and acquisition program conducts simulator-based studies and tactics development.

In 2006 FLSC delivered a simulator spin-up exercise to the SwAF for RF Alaska. That exercise was designed to cover the full mission cycles the pilots were to expect at the live exercise. The initial directive from the SwAF to FLSC for RF spin-up was to provide the same level of training. However, based on experiences from the RF Alaska spin-up/RF Alaska efforts SME (subject matter expert) pilots argued for focusing on what was called "domestics" rather than tactical execution. Domestics in this case mean the specific settings, procedures, and restrictions associated with the airfield, airspace, and the rules and regulations for the exercise. The most important experience from RF Alaska Spin-up was that the geographical and procedural familiarization the simulator exercise provided was extremely valuable during live execution. This is obviously one of the most important complements that simulated training has in relation to live training – the option of moving its users in time and space, such as evaluating different versions of a new sensor system or training in a previously unfamiliar geographical area far away from home. However, the value of having pre-trained the tactical execution in the simulator before live execution was considered less valuable with the argument that live execution of tactics in many cases and to a high extent is independent of the location. This does not mean that pre-training of tactical execution over unfamiliar terrain is not valuable, but that our experience is the value of that is considered significantly lower than the value of domestics training. However, these are experiences closely related to factors such as the fidelity of the simulation, the experience/readiness level of the participating pilots, and the objectives the exercise.

3.2 Training Objectives

With these experiences in mind the decision was made to focus on the domestics during RF Spin-up. The domestics were identified as: airfield orientation and taxiing procedures, range and target area orientation, communication protocols and procedures, airspace restrictions, and training rules and regulations. The high-level competencies that were desired to develop during RF Spin-Up came to be: familiarization with the airfield and airspace restrictions, fuel management, timings, limited air threat handling, procedures for ingress and egress, bomb drops in the target areas, taxiing procedures, and to recognize important decision points.

3.3 Exercise Management

The white force and exercise management team was a blend of US and Swedish SMEs including an F-15 aggressor pilot from Nellis AFB. This collaborative effort was made possible by a bi-lateral project arrangement, International Mission Training Research (IMTR) between USA (AFRL Mesa, AZ) and Sweden (FLSC). This group managed the exercise and provided communications for clearance delivery, Nellis AFB ground & tower, Nellis AFB arrival and departure, and AWACS (Airborne Warning and Control System) check-in/air-to-air/air-to-ground.

3.4 Exercise Setup

RF Spin-Up was conducted over 3½ days. Day one included introduction and briefs on Nellis Air Traffic Control (ATC) procedures for departure and arrival, familiarization with Nellis airspace, and a brief about the airspace. To achieve sufficient number of units during the domestic sorties, all manned pilot stations represented a unique unit. In that way they all became traffic to each other, instead of using Computer Generated Forces and a large White Force effort to simulate participating units.

Day two started with a brief on RF training rules followed by an airspace familiarization flight and practical application of the training rules in four vs. four scenarios.

During day three, two large force employment (LFE) scenarios were planned and conducted according to the authentic setup for the previous live Red Flag exercise.

Day four rounded off RF Spin-Up with one more LFE scenario and wrap up discussions. Also during the LFE scenarios, all manned stations represented a unit, tasked as offensive counter air (OCA) or air interdiction (AI) in the package. A large number of computer generated forces (CGFs), were utilized to represent hostile fighters as well as radar guided surface-to-air missile (SAM) systems.

3.5 Training Evaluation

Surveys were used to evaluate these training efforts, starting at the front of RF Spin-Up and ending after the last sortie at the live exercise. It was based on the Mission Essential Competencies (MECs) for JAS39A/B Gripen. The MEC knowledge and skills were used for the evaluation, and during SME workshops these were mapped to the SwAF official training objectives enabling later quantification of fulfilment and assessment of training effects. The same set of questions was used both for the Spin-Up and the live exercise. Some results from this evaluation have been previously reported in Castor, Borgvall, & Bennett [1]. This paper will only present qualitative experiences reported by the pilots under and after the two exercises.

3.6 Experiences

Presented below are the major experiences going from RF Spin-Up to the live Red Flag exercise. Written statements were collected from surveys during and after RF Spin-Up and Red Flag. In addition, verbal statements were recorded from the SwAF PO for Red Flag during the wrap-up workshop meeting with the simulator instructors, US and Swedish SMEs, and scientists involved in RF Spin-Up about two months after the live exercise. The written and verbal statements have been clustered by Swedish SMEs to reflect the most important positive and negative experiences.

RF SME support. One aggressor pilot from Red Flag, three AFRL SMEs, and two AFRL researchers supported the Spin-Up effort. This group in combination with the Swedish SMEs, instructors, and researchers was the single most important experience identified. The areas generated when clustering the statements were:

- White Force with Red Flag SME support
- Red Flag SME Briefings/Tutoring

Some example statements in this cluster were:

- "Important to have had the in-briefs gone through by Nellis pilot at slow pace at home in order to be able to learn at Red Flag due to extremely high pace."
- "Invaluable training to have US personnel here with extensive knowledge of Red Flag."
- "The briefs and tutoring by the Red Flag aggressor pilot supported the development of our preparations considerably."
- "We should always work like this – to bring SME competence, such as the US support in this case, for future preparatory training and rehearsal."

Domestics Training. The emphasis on learning all the domestics around the airfield and the training range with little emphasis on tactical execution was another crucial experience. The clustered areas were:

- Departure, Recovery and Arrival Routes
- Radio Communication and Procedures
- Taxi Procedures
- Geo-spatial knowledge
- Holding and Target Areas
- Distances and Timings of training range
- Fuel management
- Airspace Restrictions
- Training Rules and Regulations

Some example statements in this cluster were:

- "Once in Nellis, the Spin-Up preparations allowed us pilots to focus on mission related issues and the tactical execution instead of struggling with the complex domestics."
- "Very positive experience, much better than the RF Alaska Spin-Up where we focused on tactical execution rather than domestics which in the end did not improve our preparations of that exercise particularly."
- "The complex airspace around Nellis AFB was never an issue. The areas were quickly recognized as familiar from the simulator during the first live familiarization sortie at Red Flag."
- "All procedures and airspace around Nellis AFB were presented in a very good way by the simulations and tutor briefings."
- "Invaluable experiences of fuel management, distances, and timings."
- "Experience of radio terminology and procedures at Nellis AFB was crucial."

The SwAF pilots committed no training rule or airspace violations at their first ever participation in Red Flag, something that has never happened before, and they were formally acknowledged by the Red Flag staff for excellent communications and ground operations discipline.

Scenario Layout. The design and the pace of the scenarios at RF Spin-Up was another important experience with both positive and negative implications:

- Balance of complexity increase in the scenarios
- Lack of GBAD threat level experience
- Limited red air exposure

An example statement for this cluster was that, "The heavy GBAD [Ground Based Air Defence] threat was a surprise to everyone. Even the first sortie without red air was considered challenging". This was a particularly interesting view since it strongly related to the active choice of designing simulator scenarios lacking tactical elements providing these experiences. In other words, the pilots could have been exposed to these experiences in the simulator during the Spin-Up. Hence, the focus on domestics was very successful for the preparations but these two observations are examples of experiences the pilots missed due to limiting the tactical elements of the Spin-Up.

General Experiences. There were a few important general experiences:

- "Preparatory training such as RF Spin-Up should never be an option but a mandatory requirement."
- "The timing between the Spin-Up and RF [about 1½ months] was found to be satisfactory."

3.7 Concluding remarks

In addition to the official acknowledgement relating to the SwAF pilots domestics competence and discipline, they also received informal acknowledgement of their tactical behaviour and their professionalism throughout the live RF, and Swedish pilots acted mission commander during three sorties. The project officer stated during the wrap up workshop that this was all heavily supported by the domestics training during the Spin-Up.

Finally, it should be kept in mind that the pilots who participated were a highly skilled and proficient group. If less experienced pilots with a lower tactical readiness were to go to Red Flag the weight of the training would have to be carefully considered under the assumption they would need at least the same level of similar domestics training but also more tactical training focused on the live exercise objectives. Training needs analysis and SME involvement early on during the planning of spin up/rehearsal should provide input to this levelling of the training.

4. Training for Air Battle Managers

Andrew Robbie and Christopher Best (DSTO)

A case study strategy was employed to examine the benefits of using synthetic environments to provide mission preparation for command and control teams prior to a large-scale, live warfighting exercise. The LFE used as a vehicle for this study was Pitch Black 08, a biennial combined air and ground training exercise hosted by the RAAF and involving participants from a number of foreign military forces. Pitch Black 08 took place around RAAF Darwin and RAAF Tindal in Australia's Northern Territory during June, 2008. The broad aim of Black

Skies 08 was to test and improve the command and control in, and execution of, a multi-national coalition air campaign. One ABM team – the control team – prepared for Pitch Black 08 by supporting normal flying operations, as well as taking part in additional training tailored specifically for the live exercise. This tailored preparation commenced two weeks prior to Pitch Black 08, and consisted predominantly of practice missions which involved control of RAAF Williamtown aircrew in smaller scale missions than those seen at Pitch Black 08. A second ABM team prepared for Pitch Black 08 by taking part in Exercise Black Skies 08. The synthetic environment provided in Black Skies 08 was designed to simulate Pitch Black 08 as closely as possible in terms of mission scenarios, order of battle, airspace, procedures, and tactics.

Evaluation of the training provided in the virtual mission preparation was carried out using the four levels of criteria suggested by Kirkpatrick [2]: Information was gathered about the ABM team's reactions to the virtual mission preparation, the learning that occurred over the course of the virtual mission preparation, the impact of the virtual mission preparation on performance in the subsequent live warfighting exercise, and the broader value to the organisation of the virtual mission preparation.

4.1 Participants

Two ABM Teams from 41 Wing (WG), Surveillance and Response Group (SRG), participated in the study. Each team consisted of a Tactical Director and three Fighter Controllers in direct control roles, all of whom possessed operational experience. The Fighter Controllers were allocated to either the virtual mission preparation or control conditions by 41WG in a quasi-random manner; random allocation was constrained by the desire to produce ABM Teams that were matched in terms of the operational experience of their members, and by the availability of individual Fighter Controllers for the virtual mission preparation phase of the study.

4.2 White Force and Assessor

The execution of the virtual mission preparation was managed by a White Force consisting of a White Force Mission Director, a Red simulation operator (SIMOP) coordinator, five SIMOPs, and an Air Battle Director. The role of the White Force Mission was filled by an ex-RAAF fighter pilot. The Air Battle Director and the five SIMOPs were members of 41 WG SRG, and the Red SIMOP coordinator was a DSTO staff member who possessed operational experience as an ABM with the RAAF. The Blue SIMOPs manipulated the Blue Force air assets under the direction of the White Force Mission Director. The Red SIMOPs, under the direction of the Red SIMOP coordinator, were responsible for both manipulating the synthetic fighter assets under the control of the ABM team and simulating the communications of those aircraft pilots. The evaluation of taskwork performance and teamwork processes was carried out by an assessor from Surveillance and Control Training Unit, 41WG SRG.

4.3 The Virtual Mission Preparation Environment and Procedures

The virtual mission preparation provided for the ABM team in Black Skies 08 was designed to match, as closely as possible, the environment in which they would work and the tasks which they would be required to perform during Pitch Black 08. Black Skies 08 was comprised of a series of mission scenarios (or *vignettes*) which, over the course of the exercise, portrayed an escalation in tension between the opposing Blue and Red forces and a progression of military action. The vignettes varied in terms of training objectives, order of battle, rules of engagement, airspace, threats, and targets; they did not differ in terms of difficulty or complexity. Broadly speaking, the Blue Force participants were required to conduct a variety of missions such as offensive counter air (OCA), offensive air support (OAS), deep strike, destruction of enemy air defences, and joint personnel recovery; the Red Force participants responded by employing defensive counter air (DCA) tactics. The 41WG ABM Teams worked in shifts to provide tactical command and control support to the Red Force. For Black Skies 08, a scaled-down version of Tactical Control Centre was constructed in the Air Operations Experimentation Centre at DSTO Melbourne.

The virtual mission preparation took place two weeks prior to the commencement of Pitch Black 08. On the first day of the virtual mission preparation, the ABM team was briefed on the purpose and goals of the exercise, the exercise scenario, the manner in which their taskwork performance and teamwork processes would be evaluated, and the schedule of events. One mission was run on each day of Black Skies 08.The procedure surrounding each mission consisted of the following key events: scenario update, mission preparation, mission execution, measurement session, after action review, and exercise feedback. In the scenario update, the ABM team were briefed on expected threats, order of battle, rules of engagement (ROE), airspace, and enemy intent. The preparation time was used to plan for the impending mission. In each mission, the ABM team was required to command the air assets defending Red airspace and key points against the larger and technologically superior Blue Force.

4.4 Results

The evaluation of the training provided in Black Skies 08 was carried out using the four levels of criteria suggested by Kirkpatrick [2]: Information was gathered about the ABM team's reactions to the virtual mission preparation, the learning that occurred over the course of the virtual mission preparation, the impact of the virtual mission preparation on performance in the subsequent live warfighting exercise, and the broader value to the organisation of the virtual mission preparation. The outcomes from this study provide support for the view that synthetic training technologies can have a significant impact on the ability of RAAF warfighting teams to perform their mission in large-scale, complex, and dynamic warfighting situations. The ABM team that took part in Black Skies 08 provided positive evaluations of the training experience, their performance improved over the course of the virtual mission preparation, and during Pitch Black 08 they outperformed the ABM team that prepared for Pitch Black 08 by supporting normal flying operations. In addition, the virtual mission preparation demonstrated a broader organisational and operational value to the RAAF: it provided the White Force with the opportunity to identify deficiencies in, and mitigate risks associated with, the Pitch Black 08 mission scenarios. It also allowed the ABM Team to refine their Pitch Black 08 plans and procedures, enabling them to more effectively utilise the valuable training opportunity presented by a large-scale, live warfighting exercise.

4.5 Discussion

The principal aim of this study was to investigate the benefits of using a synthetic environment to provide mission preparation for a command and control team prior to a live warfighting exercise. Our specific research questions were couched within Kirkpatrick's [2] framework for the evaluation of training programs: Reaction, Learning, Behavioural, and Results. In respect to participants' reactions to the virtual mission preparation, the members of the ABM team that participated in Black Skies 08 reported that the exercise had considerable combat mission training value: they felt it had a positive impact on their team coordination, their tactical skills, and their overall combat mission readiness. Significantly, they believed that it provided a learning experience not available in their regular program of training. In fact, the ABM team reported that Black Skies 08 compared favourably to both regular training *and* live exercises such as Pitch Black 08 in terms of the capacity to provide training experiences critical to the ABM role. The synthetic environment was viewed as inferior to the live environment primarily in its capacity to provide training in interacting with a significant number of other command elements and external agencies. In terms of the extent to which Black Skies 08 served as an effective learning experience, the ABM team that participated in the virtual mission preparation demonstrated a marked improvement in teamwork processes, and reported an increase in collective self-efficacy and cohesion, over the course of the exercise. They also showed a clear improvement across most, but not all, of their mission essential tasks. The tasks that showed the most improvement included those associated with the control of airspace and establishing military liaison. In relation to Kirkpatrick's behavioural-level criteria, the ABM team that participated in Black Skies 08 performed better overall than the control team during the subsequent live warfighting exercise. This performance advantage was most evident in terms of superior teamwork processes.

Broadly speaking, these findings suggest that providing team training in a synthetic environment holds significant potential for the RAAF. These technologies and methods provide teams of warfighters with the opportunity to link together to engage in high-level training and mission rehearsal, and to experiment with new tactics and capabilities, more frequently – and in a more cost-effective manner – than is possible using real platforms. Conducting activities of this kind on a more frequent basis offers the potential to enhance operational readiness through training, and to accelerate improvements in organizational processes through experimentation.

5. Designing Training Events from Analysis of Training Needs

Winston Bennett (AFRL)

Training programs for combat aviators have historically centered on in-flight training. Simulation for the most part was not able to replicate the dynamic environment encountered during wartime operations. The inability to reliably and safely train in a highly realistic combat environment results in an adaptation period for aircrews during the initial stages of a conflict. This adaptation period represents a gap between what, to date, can be realistically trained and what is expected in the combat arena.

Traditional training does not take advantage of emerging capabilities in simulation. Instead, traditional training involves a range of missions in a building block approach that focuses on flight-level training and, with few exceptions, provides little complex mission training. High-fidelity simulation-simulation based approaches to training have introduced the opportunity to train more closely to the way we expect to fight -- to replicate the conditions encountered in combat, and also to record performance parameters for later analysis and learning. The Mission Essential Competencies or MECs mentioned

earlier serve as a needs-focused foundation and structure to analyze mission execution at high individual and team performance levels. They also identify the design of appropriate combinations of training media that maximize learning and skill development, ranging from individual techniques and procedures to complex mission taskings.

The importance of a needs-focused foundation for training and mission preparation cannot be understated for the work described in this paper. Historically, fighter pilot simulations in the USAF and elsewhere provided little more than procedural training in single-ship weapons employment, and instrument and emergency procedures. The capabilities of today's simulation-based training environments provide a means to train the full spectrum of mission requirements in the simulator. Synthetic natural environments replicating realistic combat conditions provide the opportunity to reliably and safely train not only mission elements, but also entire complex scenarios like those we'd expect to see in a Red Flag or other Large Force Employment event. The ability to routinely train these complex scenarios required a fresh analytical look at the overall training program, to ensure that the training advantages inherent to high-fidelity simulation are used to the greatest advantage.

MECs bridge a gap in traditional training analyses. Most training development efforts begin with a task analysis – still very important in developing initial qualification and physical requirements for simulators and training devices. However, high fidelity simulations offer the ability to train a complete mission and therefore drive analysis to the mission level. Accordingly, MECs start with the mission as performed in the combat environment.

MECs are broad in nature, but they are not abstract knowledge or general skills. They are demonstrated in the context of an actual or high-fidelity simulated mission, under wartime conditions. MECs are readily identifiable, in that they relate to overall mission processes and phases (e.g., the kill chain – Find, Fix, Track, Target, Engage, Assess (F2T2EA)), have distinct starting and end points, and if not successfully completed before going onto the next process or phase, jeopardize successful mission completion. MECs are developed by airframe; however, commonalities among different missions and aircraft will allow their aggregation into competencies oriented to "sensor-shooter" teams or packages engaged in integrated combat operations.

Training programs are tied to conditions under which the performance tasks are conducted and evaluated. For combat aviation, the true condition of performance is the combat environment, but for obvious reasons, none of us train in actual combat conditions. Training instead relies on scenarios governed by safety considerations called training rules, and is supported by ever more sophisticated ways to simulate weapons employment and record the mission as it unfolds.

Red Flag, as the premier flying training event in the USAF and routinely attended by USAF and Coalition partners, has been called the most realistic training available. Even so, Red Flag is governed by restrictive training rules that impact every aspect of operations during these LFEs. The risk of aircraft and aircrew losses in an unconstrained environment cannot be justified. Combat, however, is the true test of training. It is the ultimate condition for performance without peacetime training constraints, and replication of that environment is the key advantage of simulation training and the foundation for conducting this training needs analysis. Thus, the MEC analysis began with the definition of the combat environment. We work back from this combat environment into the specification of objectives and the design of scenarios that realistically portray combat conditions and provide the experiences in which we expect combat proficiency to develop and to be maintained.

Aircrew executing the kill chain must be able to operate over any terrain, under various weather conditions, day, or night, and in the presence of the full range of enemy countermeasures. Countermeasures such as electronic warfare can seriously degrade aircrew and weapons performance and effectiveness. We can expect an adversary that has access to the technology of information warfare, new generation air and ground threats, and integrated defenses that will challenge our ability to establish air superiority. In addition to sophisticated threats, we must be prepared to face a foe that possesses the will to oppose us rather than simply offering a token resistance. At least 50 percent of the time, one or more of the current operating theaters experience degraded weather conditions that require adverse weather capabilities. Complex political and coalition considerations and societal expectations drive stringent rules of engagement (ROE) that place even more operating constraints on warfighters. All of these conditions, separately or in combination, can be defined using our foundation, and can then drive training to support the acquisition of the knowledge, skills and experience necessary for LFE success and ultimately, combat success.

As an illustration of this foundational drive for training design and delivery, Figure 1 pictorially represents the decomposition of two tactical training scenarios according to their MEC knowledge, skill, and experience definitions – this example is from our F-16 research, but the decomposition process is identical to the one used for two of the examples in this paper.

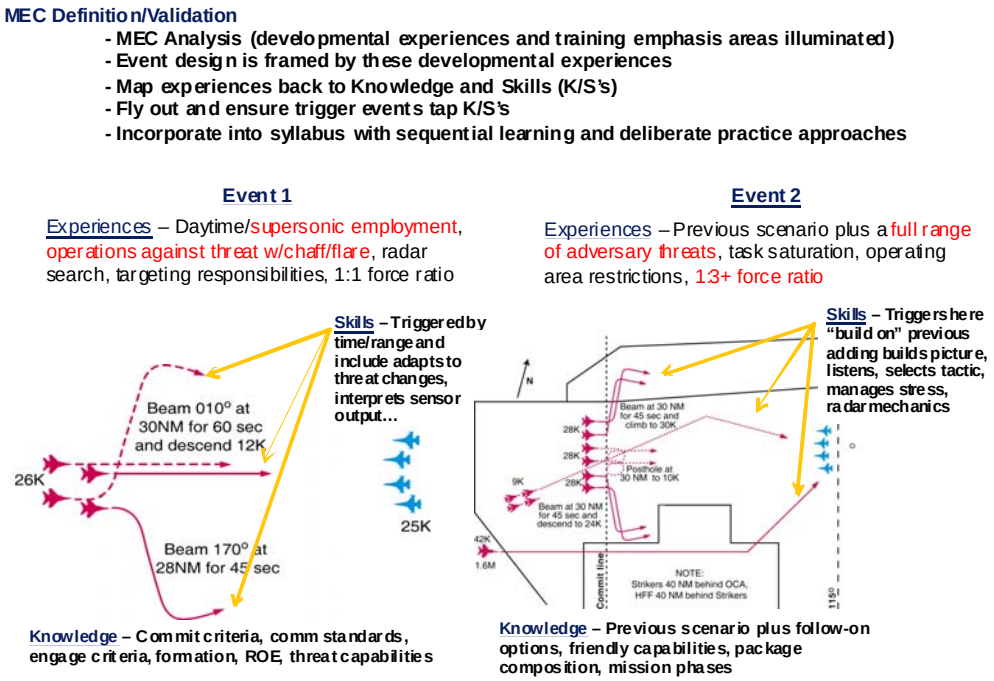

Figure 1. Anatomy of Needs Based Instructional Event Design

6. LFE Spin-up with Distributed Simulation

Michael France (AFRL)

Collaboration between AFRL and our coalition partners for large force employment spin ups for Red Flag participation has focused on two distinct types of spin up training and preparation. The first is related to spin up training that focuses on interoperable execution of tactics, techniques and procedures amongst US and coalition players prior to their participation at a Red Flag event. The second is related to focusing on the mechanics associated with coordination of ground and air operations or what we refer to here as "domestics and motherhood." Coalition live fly training in large force exercises (LFEs) such as Red Flag can be greatly enhanced with preparation through Distributed Simulation. Enhancing the LFE experience involves a great deal more than just mission rehearsal and tactical training. Each focus provided us with an opportunity to explore the potential for distributed simulation to address training objectives associated them. We will break this preparation down into the following phases:

- Domestics/Motherhood: Ground Operations, Takeoff/Departure, Range Entry, Range Orientation, Recovery (including correct controlling agency call sign and radio frequency)
- Mission Planning: Airspace Coordination Order (ACO), Air Tasking Order (ATO), Training Rules, Coalition Aircraft Capabilities & Limitations, Tactical Planning Process, Mission Materials (lineup card, map, frequency card, etc)
- LFE Training Rules Immersion
- Tactical Training: Marshalling, Push, Tactics Execution, Contingency Execution, Engagement, Egress
- After Action Review Techniques and Procedures

6.1 Domestics/Motherhood

Safely flying with other coalition members from an unfamiliar field over unfamiliar ranges can be one of the more demanding aspects of live fly LFEs. Discussions with Red Flag Leadership and Cadre have highlighted this application of local procedures as one of their greatest concerns for a safe successful exercise. Studies have shown that the demanding nature of the procedural aspects of LFEs can be reduced greatly by some basic familiarity training, provided that this training uses correct routings, procedures, call signs and frequencies. We believe that desktop trainers along with local flying publications and instruction could be used very effectively to orient aircrews to the exercise flying environment. This local area procedures orientation should reduce requirements for live fly orientation sorties prior to exercise start while increasing overall safety through greater understanding of the procedures.

6.2 Mission Planning

Tactical planning for an LFE mission is a very complex day-long effort requiring detailed understanding of the ACO, ATO, Training Rules, Aircraft Capabilities & Limitations, and Mission Materials. This detailed understanding is often gained by read ahead copies of the ACO, ATO and Mission Materials. The human interaction of planning does not generally commence until the day before exercise start, with the first mission planning cycle. We believe that mission planning using actual ACO, ATO and LFE Mission Materials for coalition DMO could jump-start both the understanding of planning requirements and the human interaction required for coalition tactical planning. Exercise participants would become intimately familiar with complex ACO and ATO information while interacting with the aircrews and C2 personnel that they will operate with during the LFE.

6.3 LFE Training Rules Immersion

When flying in actual combat, aircrew will be flying under Combat Rules of Engagement (ROE). During an LFE they will be flying under Training Rules. These training rules, like ROE will guide their tactics and execution, but are primarily used to make the exercise safer. A good example are altitude blocks, which are used to provide some measure of deconfliction of aircraft as situational awareness is built, prior to visual engagements. Combat ROE obviously does not provide this altitude deconfliction from adversaries. Generally combat training in distributed simulation exercises is executed using ROE rather than Training Rules to increase the realism and immersion for actual combat. However, during LFE spin-up we are preparing aircrews for safe successful participation in an LFE. We therefore believe that these aircrew should fly the entire spin-up under the actual LFE Training Rules that they will encounter, in order to prevent negative training transfer. We want the aircrew to spin-up for the LFE while adhering to the LFE Training Rule altitude blocks, so they become ingrained in their thinking as they execute tactics they will use in the LFE.

6.4 Tactical Training

Tactical training is ultimate LFE training objective. The tactical training in most coalition LFEs will have a graduated mission complexity level as the LFE progresses. We believe that with proper distributed simulation spin-up, mission complexity can begin at a higher level and the quality of tactical training achieved during the LFE will increase. Mission rehearsal is the key to the simulator spin-up for the tactical training during an LFE. This mission rehearsal can take the form of both large force tactics execution and rehearsing specific tactical events such as weapons delivery and threat avoidance. The value of actually "flying" tactically over the actual terrain where the LFE will be conducted cannot be overstated. Aircrew will be able to see both threat and target areas visually and through sensors replicated in the simulator environment.

6.5 After Action Review

The after action review (AAR) at LFEs in generally conducted under very specific protocols in order to effectively discover appropriate lessons learned for all LFE participants in a time efficient manner. This AAR orchestration actually has a learning curve associated with it and the tactical lessons generally become more relevant as the coalition members learn to positively interact with other LFE participants using the LFE specific AAR protocols. We believe AAR of missions flown in the simulator spin-up can be used to effectively prepare coalition participants for LFE AAR if the specific LFE AAR protocols and tools are used. This spin-up would increase tactical training early in the LFE and allow for greater mission complexity as the LFE progresses.

7. References

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Author Biographies

PETER CRANE is a Senior Research Psychologist at the Air Force Research Laboratory, Warfighter Training Readiness Division. His major research interest is enhancing effectiveness in distributed simulation systems. Dr. Crane earned a PhD in Experimental Psychology from Miami University in Ohio.

WINSTON BENNETT is a Principal Research Psychologist and team leader for training systems technology and performance assessment at the Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Readiness Research Division in Mesa, AZ. He received his PhD in Industrial/Organizational Psychology from Texas A&M University in 1995.

MICHAEL FRANCE is a retired USAF F-16 Instructor Pilot and is currently working as a Subject Matter Expert for GDIT at the Air Force Research Laboratory, Human

Effectiveness Directorate, Warfighter Readiness Research Division in Mesa, AZ.

EBB SMITH Ebb Smith is a Senior Scientist and Study Leader within the Simulation Experimentation and Collective Training team with specific expertise in the use of advanced simulation for team, collective, joint and coalition military training. Ebb is the Dstl Technical Lead for UK Mission Training via Distributed Simulation (MTDS) and until recently has been the UK lead for the Coalition Mission Training Research (CMTR) programme. CMTR is a CA, UK and US collaboration and in addition to enabling more effective training systems for the front-line has facilitated the successful exploitation of the US Mission Essential Competency process into the UK. Ebb is also the Capability Advisor for MoD's research into collective training and SEs.

BOBBY ANDERSON joined the Royal Air Force in 1974 as a navigator flying Buccaneers and Tornados until 1993. In 1999 he joined the simulation research team at Dstl Bedford as the Military Advisor. On his retirement in 2006 he joined the team as a civil servant.

JONATHAN BORGVALL is a Senior Research Psychologist and project manager in the field of training and human performance at the Swedish Air Force Combat Simulation Centre (FLSC), Swedish Defence Research Agency (FOI), in Stockholm, Sweden. He received his master of science (four years) in cognitive science from Linköping University 2002.

MARTIN CASTOR is a Deputy Research Director and project manager for human performance assessment research at FLSC, FOI. He received his PhD in Human Machine Interaction from Linköping University in 2009.

NICLAS LAGERBÄCK is a Fighter Controller / Fighter Allocator and Sector Controller from the Swedish Air Force assigned to the Operational Team at FLSC, where he is responsible for designing scenarios matching the Squadron's Training Needs. He is also an Honorably Knight of the prestigious Gripen Order.

PATRIC LAVÉN is a former fighter pilot from the Swedish Air Force. He is the head of the Operational Team at FLSC and works on Simulator Development, Training Design and other SME pilot related tasks.

ANDREW ROBBIE

CHRISTOPHER BEST is a research scientist within Air Operations Division's Crew Environments and Training branch (CET). He holds a B.A.(Hons) in Psychology (awarded in 1997) and a PhD in Psychology (awarded in 2001). His research and professional interests include human perception and cognition, human-machine interaction, team performance, and team training.